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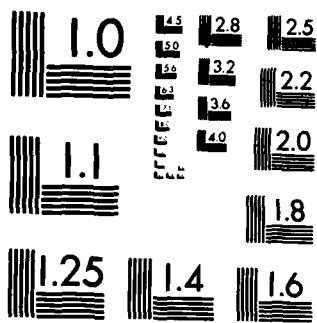
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# ON THE STRUCTURE OF INFORMATION IN SOFTWARE

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methodologies. The data suggest that the well-defined methodologies (i.e., Jackson and object-oriented) do provide advantages over the less well-defined methodology of functional decomposition. Original copy.

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## INTRODUCTION

During the contract period (15 JUL 83 - 30 SEP 84), we have been examining the role of structuring information in different ways for the production of software. Recent research suggests that errors made early in a software development project and carried on into testing and integration are the most costly type of errors to find and correct. Yet, there is almost a total absence of research examining the impact of tools and methodologies early in the process, such as in program design. This research was designed to address that need by providing theory and quantitative measures of the usefulness of a particular software development tool -- program design methodologies.

One approach to improving the design process has been the use of program design methodologies, which provide strategies to programmers for structuring solutions to computer problems. The basic difference among methodologies is the criterion used to decompose the problem into smaller units. The approaches basically vary along one dimension: the extent to which the decomposition relies upon data structures as an organizing principle for modularization. On one end of the dimension are data structure techniques that rely primarily on the data structures present in the specifications as the basis for modularization, such as the Jackson program design methodology. On the other end of the dimension are techniques that rely primarily on operations as the basis for structuring the problem, such as top-down or functional decomposition. In the former case, modules are organized around data structures, while in the latter, modules are organized around operations. Falling between the two extremes are techniques which rely partially on data structures and partially on



operations as the basis for structuring the programs, such as object-oriented design.

Using this dimension to classify methodologies, it was possible to generate programs decomposed in each of these ways. The effects of these decompositions were then evaluated in terms of the initial coding process, the quality of the resulting code, and the subsequent maintainability of the program. The focus of the research was on a comprehensive evaluation of programs produced by the different classes of methodologies.

#### RESEARCH

In this research program, we have completed one major experiment. In this experiment (Tech. Rep. 84-B1V-1), professional programmers were provided with the specifications for each of three problems and asked to produce pseudo-code for each specification. Each time the programmers worked on the program, they were asked to complete a summary sheet for the session. The intermediate versions of the programs and these summary sheets were collected for analysis. In addition, the participants were asked to complete a final questionnaire at the end of the project which provided us with information about each programmer's programming background, familiarity with the methodology, and reactions to the problems used in this research.

The measures collected were the time to design and code, percent complete, and complexity, as measured by several metrics. The results suggest that there were differences in time to code, complexity and consistency of the solutions.

## CONCLUSIONS

This research has led us to several important observations about the nature of program design methodologies and their role in the production of computer software. The data suggest that the well-defined methodologies (i.e., Jackson and object-oriented) do provide advantages over functional decomposition, which is less well-defined. These advantages would appear to be the result of the structure imposed on the development process by the methodologies.

The research further suggests that we need to be careful in generalizing our results. It would appear from this experiment that the type of problem being solved is also an important consideration in choosing a program design methodology. The results suggested that the data-driven methodologies, such as the Jackson program design methodology, may work better when the system being developed is highly data-oriented. In contrast, the object-oriented methodologies, such as object-oriented design, may work better with embedded systems, where the focus is on the objects within the system.

Overall, it would appear that program design methodologies are effective due to the guidelines they provide to the programmer, not only with regard to the formal structure of the software design process, but also with regard to the organization of the modules in the system itself.

This is in keeping with the psychological literature on problem-solving, which suggests that, at least for certain classes of problems, learning

particular strategies for attempting solutions improves performance. The results suggest that human performance in a software development task may be a function of a person's more general problem-solving abilities. Further, it suggests that principles of learning which improve problem-solving performance should also improve programming performance.

SCIENTIFIC PERSONNEL WHO WORKED ON THE PROGRAM

Deborah Boehm-Davis

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#### TECHNICAL REPORTS

Boehm-Davis, D. A. & Ross, L. S. Approaches to structuring the software development process (Tech. Rep. 84-B1V-1). General Electric Co., October 1984.

#### ARCHIVAL PUBLICATIONS

Boehm-Davis, D. A. On the structure of information in software (Abstract). In Proceedings of the 28th Annual Meeting of the Human Factors Society. Santa Monica, CA: The Human Factors Society, 1984, p. 546.

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